Polysilicon heaters **22** and **24** are buried within the silicon oxide layer **20**. The polysilicon heater **22** extends over the arm **51** which bridges across pit **32** to sample platform **16**. The intermediate portion of the heater **22** is located in the sample platform **16**. Heater **22** is provided with two wirebond terminal pads **50** and **52**. The polysilicon heater **24** follows a path across the supporting arm **55** over pit **34**, and the intermediate portion of the heater **24** is located in the reference platform **14**. The heater **24** forms a complete circuit between two wirebond terminals **54** and **56**.

The thermopile **15** is comprised of metals forming thermocouple junctions. In FIG. **1**, an aluminum line **26** leads into the structure from a wirebond pad **48** and an aluminum line **36** leads out of the structure to a wirebond pad **46**. The aluminum line **26** makes a junction **30** with a polysilicon line **28** on the sample platform **16**. The polysilicon line **28** leads to the reference platform **14** where it makes a junction **38** with another aluminum line **40**. The aluminum line **40** returns to the sample platform **16** and makes a junction **42** with a polysilicon line **44**. This series of polysilicon-aluminum junctions is repeated N times, producing a thermopile voltage $V=NV_{\Delta T}$, where $V_{\Delta T}$ is the voltage produced by a temperature difference ΔT at one of the thermocouples. A larger number N of junctions results in a greater thermopile voltage V. However, a larger number of junctions also results in a larger number of lines running between the platforms **14** and **16**, thus causing additional thermal coupling between the platforms **14** and **16**. The microcalorimeter **10** measures the difference in temperature between the platforms **14** and **16**. However, since thermal coupling between the platforms **14** and **16** reduces the accuracy of the measurement, it is preferable to weigh the benefit of increasing the thermopile voltage V with the cost associated with reducing the thermal isolation between the platforms **14** and **16**.

The use of a thermopile enables a wide operational temperature range that is potentially greater than 500° C. This wide temperature range is an important advance for applications pertaining to chemical detection and recognition based on catalytic reactions. Another advantage of the thermopile **15** is that it is able to null the effects of temperature drift in the surrounding environment and thereby enhance the thermal isolation of the device. Thus, an important aspect of the microcalorimeter **10** is that the reference and sample areas **14** and **16** are close together and thereby encounter the same environment. The thermopile **15** also enables a new sensing principle for microcalorimeters based on the detection of voltage changes due to thermal chances in the sample zone.

To calibrate the device over a desired temperature range, power is applied to heater **22** in a first step to create a temperature rise at sample zone **16** of a desired number of degrees. A similar amount of power is applied to heater **24** to create a temperature rise at the reference zone **14**. If the two zones are heated to the same temperature, the output of thermopile **15** is zero. If not, power is adjusted to achieve an approximately zero thermopile output. If digital to analog (DAC) converters are used to drive the heaters, a perfect null may not be possible. If a perfect null is not achieved, the unbalance signal is stored and subtracted during subsequent measurement operations. The power sources are not shown in FIG. **1** but it is obvious that the reference zone power source is connected to wirebond pads **54** and **56** while the sample zone power source is connected to wirebond pads **50** and **52**. Thermopile voltage to be measured appears across wirebond pads **46** and **48**.

The calibration is continued over the entire temperature range in successive steps, recording the power to each zone at each step thereby producing a power profile that provides a null (or approximately null) thermopile output voltage over the entire temperature range.

After calibration, a substance to be evaluated is placed in the sample zone. The temperature of the microcalorimeter is then changed in successive steps according to the power profile with thermopile output voltages recorded at each step. Any variation from the null is due to the reaction of the substance under test to the change in temperature.

FIG. **2** illustrates a slice of the microcalorimeter **10** in a cross-sectional elevation view taken horizontally across the chip through thermocouple junction **38** along line **2—2** of FIG. **1**. The silicon substrate **12** provides a base for the layer of silicon oxide **20**. Layers of polysilicon embedded in silicon oxide **20** form the polysilicon heaters **22** and **24**. The thermopile **15** is embedded in silicon oxide **20** and comprised of layers of polysilicon and aluminum from which lines (such as the lines **28** and **40**, respectively) are formed. Contacts between layers of polysilicon and aluminum form thermocouple junctions, such as junction **38**. The silicon oxide electrically insulates this layers of polysilicon **22**, **24**, and **28** and the aluminum layers **40** from each other. Openings in the silicon oxide layer **20** provide access to the silicon substrate **12** for surface etching of the pits **32** and **34**. FIG. **2** shows the platform **14** suspended over pit **34** and platform **16** suspended over pit **32**. The pits are separated by ridge **9**.

The microcalorimeter chip is produced using a conventional complementary metal oxide semiconductor (CMOS) process in which the layout of the silicon oxide, polysilicon, and aluminum layers is specified. The layout is used to form a mask. The conventional CMOS process determines the thickness, exact composition, resistivity, and spatial resolution of the layers in the fabricated chip. The CMOS process may be used to fabricate a microcalorimeter chip from other types of substrate materials such as gallium arsenide coupled with appropriate dielectrics and thermocouple metals. The CMOS process may also be used to fabricate amplifying and switching devices (not shown) that can be integrated into the microcalorimeter.

The silicon substrate **12** is surface etched using xenon difluoride or ethylene diamine pyrochatechol water to form the pits **32** and **34** underneath the reference and sample zones **14** and **16**. The pits **32** and **34** help to thermally isolate the reference and sample zones **14** and **16** from the silicon substrate **12**. In that manner, thermal isolation is improved to reduce heat loss to the substrate **12**, thereby enhancing the sensitivity of the microcalorimeter **10** and reducing the power required to operate the polysilicon heaters **22** and **24**.

A sample material (not shown) or a sensing material (not shown) may be deposited on the sample platform **16**. Heat changes due to chemical reactions or physical changes on the sample platform **16** are measured with respect to the reference platform **14**. Many different sensing materials may be used. For example, an absorbent material may be placed on the sample platform **16** to detect gaseous reactions. As the platforms **14** and **16** are heated, the absorbent material releases the gas, thereby providing a measurable reaction. Also, catalytic metals such as Pd, Pt, Rh, and Ni can be used on sample area **16** to generate a thermal response to hydrocarbons. High surface-area layers of reactant materials that produce heat when a specific analyte is present can be applied to the sample area **16** to enhance the sensitivity of the calorimeter **10** for those specific analytes.

As described above, the microcalorimeter **10** is preferably operated in a ramped temperature mode. The polysilicon